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Next-Generation Diversionary Devices

Mark C. Grubelich, Susan H. Fischer, and Paul W. Cooper
Sandia National Laboratories
PO Box 5800, MS-1453
Albuquerque, NM 87185-1453

ABSTRACT

Diversionary devices are of use in a wide variety of military and law-enforcement operations. They function to distract and/or incapacitate adversaries in scenarios ranging from hostage rescue to covert strategic paralysis operations.

The current Mk141 diversionary device (also known as "flash bang" or "stun grenade") is used in military and law enforcement operations. The desired results of the Mk141 are to produce a disorienting flash of light and a shock wave to temporarily incapacitate or disorient adversaries without inflicting permanent damage.

There are several disadvantages to using the Mk141. The energetic material used in the Mk141 is classed as a 1.1 explosive, making storage, transportation, and manufacture difficult. The energetic material produces a high point-source pressure (on the order of 5 ksi at the surface of the device) in order to produce the desired far-field diversionary effects. Consequently the Mk141 can produce serious injuries and fatalities in the near-field. Furthermore, smoke produced by the device hinders target acquisition.

We have been developing a next generation diversionary device to satisfy the requirements of the less-than-lethal criteria. Less-than-lethal requires the incapacitation of personnel while minimizing fatalities, permanent injury, and unplanned collateral damage. This next-generation device is capable of producing the desired far-field diversionary effects without high near-field pressures. This device also exhibits reduced smoke production which allows for easier target acquisition

We have demonstrated proof-of-concept of the next-generation diversionary device. The next step will be to develop a prototype device.

Designated points of contact for this work are Mark Grubelich, (505) 844-9052, mcgrube@sandia.gov and Susan Fischer, (505) 845-8092, shfisch@sandia.gov.

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INTRODUCTION

Diversionary devices are used in a wide variety of military and law-enforcement operations. They function to distract and/or incapacitate adversaries in scenarios ranging from hostage rescue to covert strategic paralysis operations.

There are a number of disadvantages associated with currently available diversionary devices. Personnel safety is of paramount importance as serious injuries and fatalities have resulted from their use both operationally and in training .

Desired improvements to these devices include protection against inadvertent initiation, lower smoke production, the elimination of the production of high-velocity fragments, and increased light output.

We have been developing a next-generation diversionary flash-bang device that would provide increased safety, lower smoke production, no secondary high-velocity fragments, higher light output, and the potential for user-tailorable output.

BACKGROUND

In the United States, the first diversionary devices used were M116A1 hand-grenade simulators. The M116A1 used a pull-wire fuze lighter and a piece of time-delay blasting fuze that provided a delay of 15 to 30 seconds. This device contained 35 grams of a photoflash mix.

The FBI Hostage Rescue Team modified the M116A1. An M301 fuze assembly, used in smoke grenades, was employed to provide a shorter (two-to-four-second) delay. This was done by removing the pull-wire fuze lighter and delay fuze. The M301 fuze was installed in the cardboard body of the M116A1; a potting compound was used to seal the assembly. Problems associated with these devices included occasional flashthroughs in the fuze assembly (leading to "instantaneous" functioning), fuze function failures, the ejection of the fuze at potentially lethal velocities ranging from 80 fps to 180 fps, fires as a result of smoldering cardboard body fragments, and excessive smoke production.

As a result of the US military's requirement for an next-generation operational device, Sandia National Laboratories was asked to design a device addressing these problems. The new device, the Mk141 mod 0 device, contained 17.5 grams of flake aluminum and potassium perchlorate flash powder. Less smoke was produced due to the decrease in the amount of material in the charge as well as better combustion efficiency. The design had a molded plastic fuze assembly which eliminated flash-through problems. It was ejected at a low velocity (~20 fps) prior to the ignition of the flash powder. This was accomplished by igniting a small pyrotechnic charge which separated the fuze assembly from the Mk141's main body. A short delay column, integral to the main body, subsequently ignited the flash-powder charge which functioned within approximately a foot of where it was thrown. The body was made of fire-retardant urethane foam to eliminate any high-velocity high-density fragments and to reduce the probability of secondary fires. The body was colored black for covert operations.

The original M116A1, the modified M116A1, and the Mk141 are pictured in Figure 1. Figure 2 shows a disassembled Mk141.

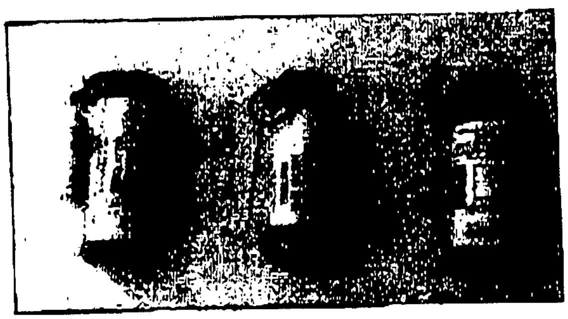

Figure 1. M116A1 mod 0, M116A1 mod 1, and Mk141.

Figure 2. Disassembled Mk141.

PERFORMANCE OF THE Mk141

The Mk141 produces an internal pressure of about 27 ksi with a rapid rise to the peak pressure, as is shown in Figure 3. This peak side-on pressure decays with distance as is shown in Figure 4. This overpressure, combined with intense light output (which has never been characterized), temporarily distracts and/or incapacitates adversaries.

Unfortunately, the contact and very near-field effects of the Mk141 are of sufficient magnitude to cause permanent injuries and/or fatalities due to the overpressure as well as high-velocity secondary fragments. The degree of injury depends on peak pressure and the duration of the overpressure wave.

Survival curves have been compiled for a number of conditions. Figures 5, 6, and 7 show these curves for several orientations of the subject with respect to the shock wave. The damage thresholds also depend on the presence or absence of a reflecting surface close to the subject. This effect is illustrated by comparing Figures 6 and 7. Similar curves are available for ear damage. The threshold for eardrum rupture is about 4 psi.

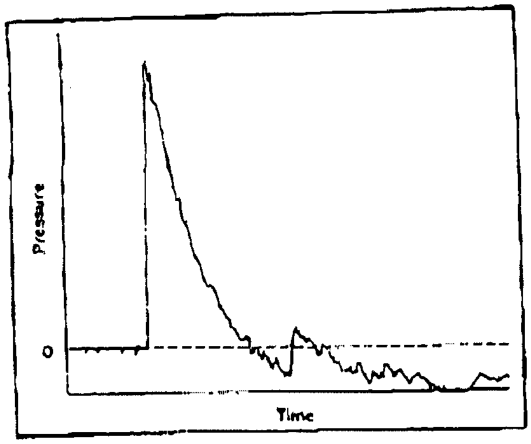

Figure 3. Typical pressure trace for the Mk141.

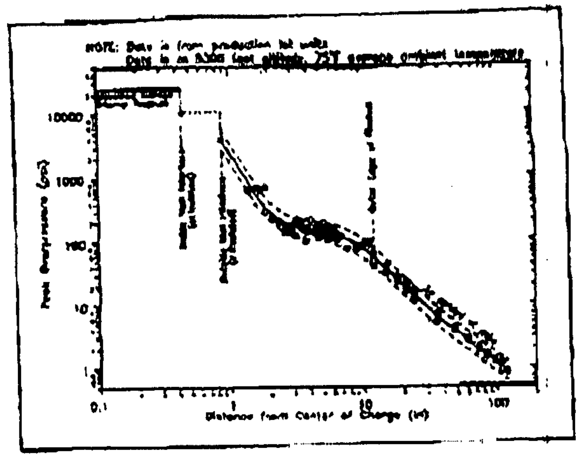

Figure 4. Pressure vs distance data for the Mk141.

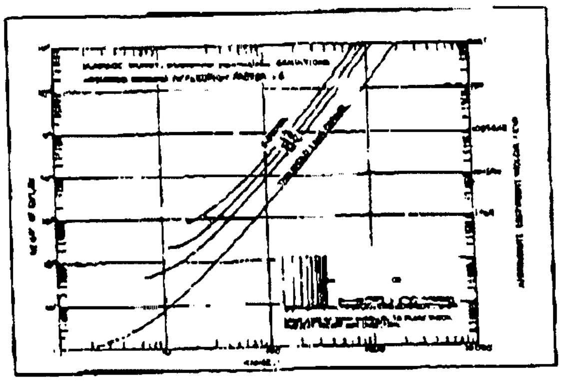

Figure 5. Predicted survival curves for man exposed in the free stream to surface burst of TNT where the long axis of the body is parallel to the blast winds.

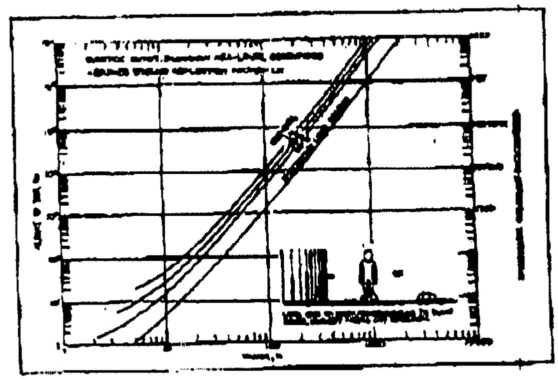

Figure 6. Predicted survival curves for man exposed in the free stream to surface bursts of TNT where the long axis of the body is perpendicular to the blast winds.

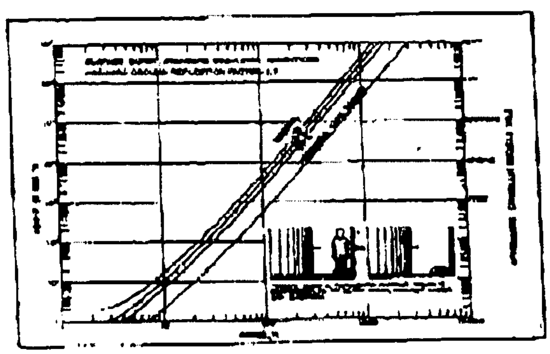

Figure 7. Predicted survival curve for man exposed to surface bursts of TNT where the thorax is near a flat rigid surface reflecting the blast wave at normal incidence.

Other safety concerns also exist. The Mk141 utilizes a "flash powder" mix of potassium perchlorate and aluminum which is a class 1.1 explosive. This material is sensitive to shock, thermal, electrostatic, and mechanical ignition stimuli. These devices are also susceptible to sympathetic detonation and initiation by bullet impact. Additionally, the Mk141 device must be handled as a destructive device during storage and shipping as it is, effectively, a small bomb.

NEXT-GENERATION FLASH-BANG DIVERSIONARY DEVICE

General Description

Based on recent research, coupled with the desire for an improvement in safety, a safer and more versatile diversionary device can be developed using the combustion of a fuel delivered by the device and the oxygen present in the ambient air. This next-generation device ejects a powdered fuel that mixes with ambient air and then auto-ignites. (This process is similar to the ignition of propellant gases in guns resulting in a "muzzle flash" event or the ignition of dust in a grain-elevator explosion). The operation of this device produces a fuel-air combustion reaction. Since a combustion process is more spatially and temporally diffuse than the detonation of an explosive, a longer pressure pulse with a slower rise to the peak pressure results. This produces a near-field peak overpressure that is several orders of magnitude lower than that of the Mk141. The desired far-field effects of acoustic and visual alarm are preserved.

Advantages

There are many advantages of this next-generation flash-bang device.

- Due to the reduced near-field peak overpressure, the possibility of permanent damage to subjects exposed to the near-field pressure wave would be greatly reduced.
- The acceleration of any near-field objects produced by the overpressure would be less, making serious injury due to secondary high-velocity fragments much less likely.
- The nonexplosive nature of the powdered-metal fill would allow the devices to be stored and shipped with fewer (if any) restrictions.
- The fuel-air reaction will produce less smoke since the products of combustion would not contain potassium chloride. Thus, target acquisition upon entry would be enhanced.
- The next-generation diversionary device's "yield" could be customized in the field. The acoustic and light output could be adjustable by increase or decrease of the fuel charge during each particular operational scenario.

Metal Powder Fuels

For the next-generation diversionary flash-bang device discussed here, aluminum was selected for the fuel. Fine aluminum particles have high reactivity in air and good combustion efficiency without being pyrophoric. This is accomplished commercially by passivating even submicron aluminum particles to produce a thin inert aluminum-oxide layer while still allowing the underlying aluminum to remain active.

EXPERIMENTAL CHARACTERIZATION

In preliminary tests, we have demonstrated proof-of-concept of the next-generation diversionary device. This was accomplished by expelling twenty-five grams of 3μ aluminum powder (Valimet H3) from a one-inch inside-diameter by six-inch-long tube with 2.5 grams of 4Fg black powder (used as a gas generator and igniter charge). The residual hot gases and particles from the black powder ignite the aluminum powder as it mixes with air.

The experimental setup is illustrated in Figure 8. The test configuration allows the aluminum powder to be launched vertically resulting in a very directional output. This potentially allows for next-generation coupling to the target.

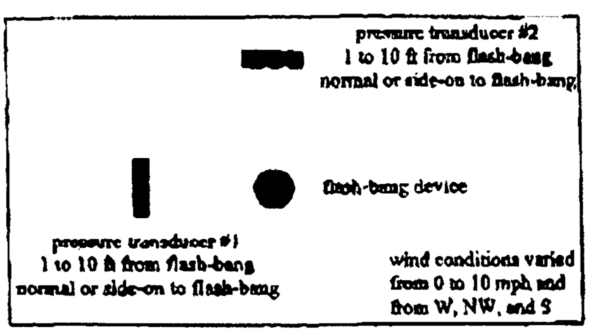

Figure 8. Experimental setup for pressure measurements of a next-generation flash-bang device.

The overpressure was measured at distances from one to ten feet from the device. We oriented the pressure transducers to measure the total (reflected) as well as side-on overpressure. A pressure trace from these preliminary tests is shown in Figure 9. As was seen in Figure 3, the Mk141 produces a shock wave with a rapid ("instantaneous") rise to the peak pressure and an exponential decay. The pressure curve of the next-generation flash-bang device is markedly different. The pressure rise is much more gradual and the peak pressure is significantly lower. When the next-generation flash-bang device functions, a combustion wave rather than a detonation wave proceeds through the fuel-air mixture .

Figure 10 shows several stills from a videotape of one of these proof-of-concept test.

CONCLUSION

We have demonstrated proof-of-concept of a next-generation flash-bang diversionary device. This new design has many advantages over existing flash-bang devices, including less potential for serious injury and fatalities, increased safety from inadvertent initiation, fewer storage and transportation restrictions, lower smoke production, and field-adjustable output.

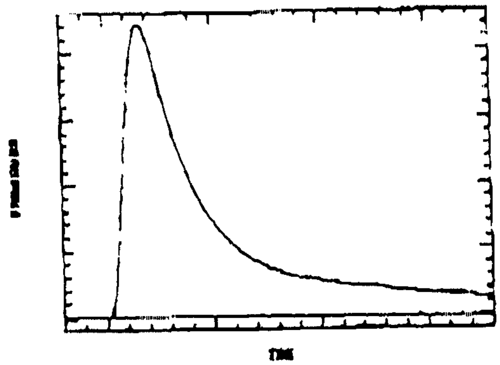

Figure 9. Typical pressure vs time curve from preliminary next-generation flash-bang experiments.

The next step will be to develop a prototype device.

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Figure 10. Sequence of eight stills taken from a videotape of one of the preliminary next-generation flash-bang experiments.